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Global Impact of the COVID-19 Pandemic on Solid Organ Transplant

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ABSTRACT

Background. COVID-19 has drastically affected transplant services, but there is limited understanding of the discrepancy of COVID-19 effects on various regions of the world.

Methods. We have explored the Global Observatory for Organ Donation and Transplantation data for assessing the transplant number changes between the calendar year 2019 (n = 157,301) and 2020 (129,681).

Results. There was a disproportionate impact of COVID-19 on different areas of the world. Globally, there was a decline of 17.5%, in which deceased donation, kidney (20.9%), pancreas (16.2%), lung (12.7%), liver (11.3%), and heart (8%) transplant declined disproportionately in different regions of the world. The pandemic affected almost all geographic regions and nations, but China and the United States were mostly able to recover from the initial halt of the transplant practices by the pandemic so that there was a cumulative increase in transplant numbers.

Conclusions. Our data show that developing nations lagged behind, whereas developed nations have been able to recover their transplantation programs during the pandemic. Further policy making and preparedness is required to safeguard the most vulnerable areas of the world to minimize the impact of any future pandemic on transplantation practices.

GLOBALLY, as of January 21, 2022, there have been 340,543,962 confirmed cases of COVID-19, including 5,570,163 deaths, reported to the World Health Organization. As of January 18, 2022, a total of 9,571,502,663 vaccine doses have been administered. COVID-19 has reached almost all parts of the world, with a fiercer impact in America and the Indian subcontinent [1]. Transplantation communities across all regions of the world have been affected [2,3]. Of additional concern are data showing that solid organ transplant (SOT) recipients had higher mortality rates [4]. SOT was drastically affected by COVID-19 in many countries worldwide including the United States [5], France [6], Spain [7], Australia [8], China [9], and India [10]. Deceased donation (DD) was most affected in developing nations, whereas live donations have been more prominently affected in developed nations. Differences in transplant rates among developed and developing nations may be addressed by establishing and optimizing deceased donor programs [11] in developing nations and

expanding living donor transplantation programs in developed nations. The aim of this report was to explore the different impacts of COVID-19 on transplant services in different regions of the world.

MATERIALS AND METHODS

We explored the Global Observatory for Organ Donation and Transplantation database for transplant numbers from various geographic areas and compared the percentages in the years 2019 and 2020. No ethical committee review was required because this is a secondary analysis

All data will be made available from the corresponding author on request.

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of the publicly available database for transplantation. Data are summarized as absolute numbers and in per million population. The data were expressed as frequencies and percentages. No statistical analysis was used for the report.

RESULTS

We analyzed data from the Global Observatory for Organ Donation and Transplantation for the years 2019 and 2020 [12] and present details on how SOT activities have been affected by the pandemic, with concentration on 6 geographic regions (Table 1) of the World Health Organization (Africa, America, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific), including those that have been most affected by COVID-19 (Table 2). Globally, DD declined by 11.5%, and the decrease in DD was most dominant on the Indian subcontinent (50.9%), followed by the Eastern Mediterranean region (40.2%), the UK (24.5%), Europe (19.6%), Brazil (19.6%), the Western Pacific Region (10%), and America (3.5%). Globally, donation after circulatory death (DCD) declined at a lower rate than donation after brain death (DBD) (9% vs 12.2%). Conversely, in the western pacific region, DCD declined by 25% compared with an increase in DBD by 11% from the pre-pandemic year. Furthermore, in contrast to other areas of the world, in the United States DCD improved by 12% and DBD improved by 2%. Globally, living donor kidney transplant (LDKT) has been most affected, with a 33% decline. In India, the steepest decrease has been seen for DDKT (54.6%) compared with a 42.3% drop for LDKT. Globally, the decline in LDKT was most prominent in the Eastern Mediterranean region (60%), followed by the Brazil (58.4%), the UK (45.4%), India (42.3%), America (38%), Europe (23.8%), and the United States (23.7%). Globally liver transplant declined by 11%. Overall, liver transplant numbers dropped most prominently in the Eastern Mediterranean region (42.3%), followed by the South East Asian region (29%), India (31.3%), the UK (15.2%), Europe (14.1%), America (5%), and the western pacific (4%). Globally, deceased donor liver transplant declined relatively less, with 10% compared to a decline of 12% in living donor liver transplant. Overall, liver transplant centers in the United States have been able to recover quickly after an initial drop. Similarly, China has shown the most rapid recovery in their transplantation programs; in fact, the numbers increased in 2020, contrary to others. Globally, intestinal or small bowel transplants (SBTs) increased by 8.2%. Pancreas transplants declined globally, particularly in the UK (37.2%), followed by India (36.3%), the Western Pacific Region (34.9%), the Eastern Mediterranean (29.7%), Europe (22.2%), Brazil (16.3%), and America (9.7%). Overall, heart transplantation saw a decline of 8.4%. Heart transplants decreased most in India (52.4%). Based on our data analysis, lung transplants declined by 12.7 % globally, with a drop of 51% in the Eastern Mediterranean region, followed by India (41.2%) and the UK (40.7%).

Table 1. Donation and Transplant Activities in 2019 vs 2020, According to Data Derived From the Global Observatory on Donation and Transplantation Stratified by Geographic Region [11]

Region Year	Eastern Mediterranean			Africa			Western Pacific			Europe			America			South East Region		
	2019	2020		2019	2020		2019	2020		2019	2020		2019	2020		2019	2020	
Deceased donors	1241 (2.78)	741 (1.58)	1 (0)	1 (0)	(-)	(-)	7066 (3.96)	6355 (3.52)	13,388 (16.92)	10,755 (12.69)	18,146 (18.62)	17,510 (17.79)	1016 (0.63)	764 (0.47)				
DBD	1241 (2.78)	741 (1.58)	1 (0)	1 (0)	(-)	(-)	2940 (1.65)	3292 (1.82)	11,233 (14.2)	9063 (10.7)	15,428 (15.83)	14,090 (14.32)	1016 (0.63)	760 (0.46)				
DCD	(-)	(-)	(-)	(-)	(-)	(-)	4126 (2.31)	3063 (1.7)	2155 (2.72)	1692 (2)	2718 (2.79)	3420 (3.48)	(-)	4 (0)				
KT	5536 (12.42)	2520 (5.36)	470 (1.33)	413 (0.86)	(-)	(-)	18,194 (10.19)	16,446 (9.1)	28,053 (35.45)	21,929 (25.88)	39,515 (40.54)	32,957 (33.49)	10,635 (6.62)	6661 (4.07)				
DDKT	1578 (3.54)	940 (2)	2 (0.01)	2 (0.01)	(-)	(-)	12,491 (6.99)	11,266 (6.24)	20,287 (25.64)	16,019 (18.9)	28,035 (28.76)	25,841 (26.26)	1698 (1.06)	1192 (0.73)				
LDKT	3958 (8.88)	1580 (3.36)	468 (1.32)	413 (0.86)	(-)	(-)	5703 (3.19)	5180 (2.87)	7766 (9.81)	5910 (6.97)	11,480 (11.78)	7116 (7.23)	8937 (5.56)	5469 (3.34)				
LT	1612 (3.62)	930 (1.98)	12 (0.03)	2 (0)	(-)	(-)	8589 (4.81)	8175 (4.52)	10,754 (13.59)	9228 (10.89)	13,070 (13.41)	12,335 (12.54)	2708 (1.69)	1916 (1.17)				
DDLT	99 (0.22)	60 (0.13)	1 (0)	1 (0)	(-)	(-)	6205 (3.47)	5772 (3.19)	8963 (11.33)	7590 (8.96)	12,166 (12.48)	11,467 (11.65)	697 (0.43)	396 (0.24)				
LDLT	552 (1.24)	264 (0.56)	11 (0.03)	2 (0)	(-)	(-)	2377 (1.33)	2388 (1.32)	1774 (2.24)	1631 (1.92)	887 (0.91)	862 (0.88)	2009 (1.25)	1518 (0.93)				
Heart Tx	179 (0.4)	98 (0.21)	(-)	(-)	(-)	(-)	1092 (0.61)	949 (0.53)	2853 (3.61)	2513 (2.97)	4506 (4.62)	4419 (4.49)	218 (0.14)	122 (0.07)				
Lung Tx	49 (0.11)	24 (0.05)	(-)	(-)	(-)	(-)	948 (0.53)	922 (0.51)	2327 (2.94)	1878 (2.22)	3369 (3.46)	3048 (3.1)	114 (0.07)	68 (0.04)				
Pancreas Tx	37 (0.08)	26 (0.06)	(-)	(-)	(-)	(-)	169 (0.09)	110 (0.06)	763 (0.96)	593 (0.7)	1358 (1.39)	1226 (1.25)	25 (0.02)	15 (0.01)				
Small bowel Tx	10 (0.02)	7 (0.01)	(-)	(-)	(-)	(-)	2 (0)	5 (0)	39 (0.05)	40 (0.05)	95 (0.1)	99 (0.1)	(-)	7 (0)				
Total organ Tx	7423 (16.65)	3605 (7.67)	482 (1.36)	415 (0.87)	(-)	(-)	28,994 (16.23)	26,607 (14.73)	44,789 (56.6)	36,181 (42.7)	61,913 (63.52)	54,084 (54.96)	13,700 (8.53)	8789 (5.37)				

DBD, donation after brain death; DCD, donation after circulatory death; DDKT, deceased donor kidney transplant; DDLT, deceased donor liver transplant; DLT, living donor liver transplant; LDKT, living donor kidney transplant; LT, liver transplant; Tx, transplant.

Table 2. Donation and Transplantation Activities in 2019 vs 2020, According to Data Derived From the Global Observatory on Donation and Transplantation Stratified by Most Affected Nations [11]

Year	India			United Kingdom			Brazil			China			United States			Global		
	2019	2020		2019	2020		2019	2020		2019	2020		2019	2020		2019	2020	
Deceased donors	715 (0.52)	351 (0.25)		1653 (24.67)	1248 (18.38)		3767 (17.74)	3027 (14.24)		5818 (4.07)	5222 (3.61)		11,870 (36.07)	12,588 (38.03)		40,858 (6.86)	36,125 (5.81)	
DBD	715 (0.52)	347 (0.25)		964 (14.39)	814 (11.99)		3767 (17.74)	3027 (14.24)		1906 (1.33)	2315 (1.6)		9152 (27.81)	9364 (28.29)		31,859 (5.35)	27,946 (4.49)	
DCD	(-)	4 (0)		689 (10.28)	434 (6.39)		(-)	(-)		3912 (2.74)	2907 (2.01)		2718 (8.26)	3224 (9.74)		8999 (1.51)	8179 (1.31)	
KT	9751 (7.12)	5486 (3.98)		3649 (54.46)	2567 (37.81)		6298 (29.65)	4830 (22.72)		12,124 (8.49)	11,037 (7.63)		24,273 (73.76)	23,644 (71.43)		102,403 (17.19)	80,926 (13)	
DDKT	1138 (0.83)	516 (0.37)		2627 (39.21)	2009 (29.59)		5227 (24.61)	4385 (20.63)		10,389 (7.27)	9399 (6.49)		17,406 (52.89)	18,410 (55.62)		64,091 (10.76)	55,258 (8.88)	
LDKT	8613 (6.29)	4970 (3.6)		1022 (15.25)	558 (8.22)		1071 (5.04)	445 (2.09)		1735 (1.21)	1638 (1.13)		6867 (20.87)	5234 (15.81)		38,312 (6.43)	25,668 (4.12)	
LT	2,92 (1.89)	1780 (1.29)		971 (14.49)	823 (12.12)		2265 (10.66)	2075 (9.76)		6170 (4.32)	5842 (4.04)		8896 (27.03)	8906 (26.91)		36,745 (6.17)	32,586 (5.24)	
DDLT	599 (0.44)	291 (0.21)		948 (14.15)	801 (11.8)		2101 (9.89)	1933 (9.09)		5332 (3.73)	4954 (3.42)		8372 (25.44)	8415 (25.42)		28,131 (4.72)	25,285 (4.06)	
LDLT	1,991 (1.45)	1487 (1.08)		22 (0.33)	22 (0.32)		156 (0.73)	141 (0.66)		831 (0.58)	874 (0.6)		516 (1.57)	486 (1.47)		7610 (1.28)	6665 (1.07)	
Heart Tx	187 (0.14)	89 (0.06)		188 (2.81)	179 (2.64)		383 (1.8)	308 (1.45)		679 (0.48)	557 (0.38)		3597 (10.93)	3716 (11.23)		8848 (1.49)	8101 (1.3)	
Lung Tx	114 (0.08)	67 (0.05)		167 (2.49)	99 (1.46)		106 (0.5)	65 (0.31)		489 (0.34)	513 (0.35)		2759 (8.38)	2597 (7.85)		6807 (1.14)	5940 (0.95)	
Pancreas Tx	22 (0.02)	14 (0.01)		185 (2.76)	116 (1.71)		177 (0.83)	148 (0.7)		(-)	(-)		1015 (3.08)	962 (2.91)		2352 (0.39)	1970 (0.32)	
Small bowel Tx	(-)	7 (0.01)		18 (0.27)	17 (0.25)		3 (0.01)	1 (0)		(-)	(-)		81 (0.25)	91 (0.27)		146 (0.02)	158 (0.03)	
Total organ Tx	12,666 (9.25)	7443 (5.39)		5178 (77.28)	3801 (55.98)		9232 (43.47)	7427 (34.93)		17,949 (12.4)	40,621 (123.43)		39,916 (120.59)	157,301 (26.4)		129,681 (20.84)		

Data are arranged from right to left as worst affected to least affected nations; data in parentheses is expressed in per million population. DBD, donation after brain death; DCD, donation after circulatory death; DDKT, deceased donor kidney transplant; DDLT, deceased donor liver transplant; DLT, living donor liver transplant; LDKT, living donor kidney transplant; LT, liver transplant; Tx, transplant.

DISCUSSION

Our report clearly highlights the different effects and recovery rates of transplant services across the world. The discrepancy in decline of DD in different areas emphasizes the need to optimize DD policies and practices in emerging societies, with DD expected to be most vulnerable during future pandemics. Those data indicate that DCD is playing an important role in contributing to an optimized utilization of available organs for transplant in developed countries. Indeed, recent high-level data support that well-established DD programs show also favorable outcomes with DCD [13,14]. Ratios of DCD to DBD in addition to hospital and staff capacities may also play a role. In the initial phase of the pandemic, many regions have avoided DCD or marginal organs for fear of prolonged hospital stays and a higher probability for complications. Clearly, optimizing the balance between available resources with an enhanced utilization of available organs will be most relevant in preparing for the next pandemic. Additionally, support by the global community to strengthen DD programs will help improve transplantation in emerging countries moving forward.

This trend for a better response in living donation practices during the pandemic in nations such as India may be explained with an effective application of guidelines for living donor transplantation [15]. Moreover, DD is still in its infancy in emerging countries, whereas logistics for resuming DD during the pandemic were highly unfavorable and less prioritized [16,17]. Additionally, the decline of LDKT differed between public and private sector hospitals in India [18]. Living donation remained suspended in major public sector programs for an extended period with the care of patients with COVID-19 considered a health emergency. With treatment alternatives for end-stage kidney disease and LDKT being mostly elective, the drop in LDKT is not entirely surprising. In addition, there is still wide variation in testing strategies and protocols for transplantation in the pandemic across different centers worldwide.

SBT is mostly an emergent procedure, and the rising volume indicates the success of the policies for a smooth conduct of emergency operations during the pandemic [19]. Notably, SBTs are performed in low numbers independent from the pandemic and data may thus need to be interpreted with caution. An interesting case report of a SBT post COVID-19 in a child who developed small bowel gangrene subsequent to a superior mesenteric artery thrombosis has been reported recently [20]. Although a rare complication of COVID, it is expected that transplants in patients developing end-stage organ failure subsequent to COVID will become more frequent. From the aforementioned analysis, it is becoming clear that the impact of COVID-19 on transplant volumes differs by organs and region. Effective policies and risk stratification may help to move transplantation forward (Table 3) [21] in case of future pandemics.

CONCLUSIONS

A careful and continuing analysis will be necessary to delineate the consequences of COVID-19—related challenges in different

Table 3. Pandemic Preparedness Plan

<ul style="list-style-type: none"> • Rapid implementation of telemedicine, telehealth, machine learning, and remote monitoring for follow-up • Assessing the scope of home-based therapy, door-step health care delivery • Ensuring safety of health care personnel • Increasing access to vaccines, nonpharmaceutical public health measures to prevent the spread • Addressing knowledge gaps and working toward a research preparedness network • Prompt assessment of logistics and pandemic surge during procurement to minimize waste of organs • Effective and safe restoration of transplantation with team-work • Development of an early regional plan tackling any pandemic surge • Prioritizing waitlisted candidates for an early transplant • Relaxing routine testing protocols of donor/recipient for transplant • Rapid testing of the pathogen • Early segregation of affected individuals from noninfected ones • Consensus statements for any change in immunosuppression
<p>Long-term policy and practices</p> <ul style="list-style-type: none"> • Political mobilization and priority in managing the transplantation practices, integration, financing, resilience, and equity • National and international support, collaboration, and need for global cooperation for expanding organ donation • Improving legal and institutional framework, improvement of hospital and ICU protocols for transplant • Funding sources should be prioritized to organ donation practices • Leadership at all levels, right from transplant coordinators to higher authorities • Promoting education and updates at all levels during the pandemic • Implementing technological infrastructure, capacity, care, collaboration building and financial stability in preparation of future pandemics • Universal health care, international efforts to reinforce global health security, international health regulation, international pandemic treaty • Funders, policymakers, infectious disease, and public health authorities need to remain vigilant, maintain surveillance, and continue to plan for future pandemics

ICU, intensive care unit.

geographic areas and health care systems. The restoration of transplantation activities has been well under way in developed nations including the United States, despite being the most affected. Transplant volumes varied across geographic areas and depended also on overall stability of health care. As an example, developing nations including India that have been overwhelmed by the increasing demand of taking care of patients with COVID will have less capacity to transplant. Strengthening DD programs particularly in developing countries will be of paramount importance. The stability of deceased donor organ systems in some countries including the United States has shown that the decline of transplant volumes can be compensated for quickly. Organ-specific discrepancies in transplantation rate can be explained on the basis of varying urgency for different organ failures. Mutual support and international cooperation, bold policy and guidelines, and continued shared knowledge and research is needed to respond to future pandemics. That being said, we understand that the transplant community has done an excellent job in communicating information rapidly.

REFERENCES

- [1] World Health Organization. WHO Coronavirus (COVID-19) Dashboard <https://covid19.who.int/>; 2022 [accessed 22.01.22].
- [2] Ahn C, Amer H, Anglicheau D, et al. Global transplantation COVID report March 2020. *Transplantation* 2020;104:1974–83.
- [3] Azzi Y, Bartash R, Scalea J, Loarte-Campos P, Akalin E. COVID-19 and solid organ transplantation: a review article. *Transplantation* 2021;105:37–55.
- [4] Hadi YB, Naqvi SFZ, Kupec JT, Sofka S, Sarwari A. Outcomes of COVID-19 in solid organ transplant recipients: a propensity-matched analysis of a large research network. *Transplantation* 2021;105:1365–71.
- [5] Cholaneril G, Podboy A, Alshuwaykh OS, et al. Early impact of COVID-19 on solid organ transplantation in the United States. *Transplantation* 2020;104:2221–4.
- [6] Zaidan M, Legendre C. Solid organ transplantation in the era of COVID-19: lessons from France. *Transplantation* 2021;105:61–6.
- [7] Domínguez-Gil B, Fernández-Ruiz M, Hernández D, et al. Organ donation and transplantation during the COVID-19 pandemic: a summary of the Spanish experience. *Transplantation* 2021;105:29–36.
- [8] Chadban SJ, McDonald M, Wyburn K, Opdam H, Barry L, Coates PT. Significant impact of COVID-19 on organ donation and transplantation in a low-prevalence country: Australia. *Kidney Int* 2020;98:1616–8.
- [9] Kute VB, Meshram HS, Mahillo B, Dominguez-Gil B. Transplantation in India and China during the COVID-19 pandemic. *Lancet Public Health* 2022;7:e12.
- [10] Kute VB, Bhalla AK, Guleria S, et al. Clinical profile and outcome of COVID-19 in 250 kidney transplant recipients: a multicenter cohort study from India. *Transplantation* 2021;105:851–60.
- [11] Matesanz R, Domínguez-Gil B, Coll E, Mahillo B, Marazuela R. How Spain reached 40 deceased organ donors per million population. *Am J Transplant* 2017;17:1447–54.
- [12] Global Observatory on Donation and Transplantation. Summary <http://www.transplant-observatory.org/summary/>; 2021 [accessed 21.01.22].
- [13] Pruett TL, Vece GR, Carrico RJ, Klassen DK. US deceased kidney transplantation: estimated GFR, donor age and KDPI association with graft survival. *EClinicalMedicine* 2021;37:100980.
- [14] Gill J, Rose C, Lesage J, Joffres Y, Gill J, O'Connor K. Use and outcomes of kidneys from donation after circulatory death donors in the United States. *J Am Soc Nephrol* 2017;28:3647–57.
- [15] Gupta S, Sudhindran S, Saraf N, et al. Liver Transplant Society of India guidelines for liver transplant during COVID-19 times. *J Clin Exp Hepatol* 2022;12:180–5.

[16] Kute V, Ramesh V, Shroff S, et al. Benefit to few versus risk to many: an ethical dilemma during coronavirus disease 2019 pandemic for deceased-donor organ transplant in a resource-limited developing country. *Exp Clin Transplant* 2021;19:1–7.

[17] Stock PG, Wall A, Gardner J, et al. Ethical issues in the COVID era: doing the right thing depends on location, resources, and disease burden. *Transplantation* 2020;104:1316–20.

[18] Meshram HS, Kute VB, Swarnalatha G, et al. Effect of Coronavirus Disease 2019 on Transplantation and Nephrology in India: A Nationwide Report From India [published online ahead of print, 2021

Oct 2]. *Transplant Proc.* 2021;S0041-1345(21)00684-9. doi: [10.1016/j.transproceed.2021.09.008](https://doi.org/10.1016/j.transproceed.2021.09.008)

[19] Diaz A, Sarac BA, Schoenbrunner AR, Janis JE, Pawlik TM. Elective surgery in the time of COVID-19. *Am J Surg* 2020;219:900–2.

[20] Chaubal G, Hatimi H, Nanavati A, et al. Pediatric living donor intestine transplant following an atypical complication of COVID-19: a unique case report from India. *Am J Transplant* 2021;21:4079–83.

[21] OPTN. Public comment proposal: COVID-19 emergency policies and data collection https://optn.transplant.hrsa.gov/media/3926/covid-19_emergency_policies_data_collection_pc.pdf; 2021 [accessed 21.11.10].